# STABILIZATION OF UNSTABLE ROADFILL USING EXPLOSIVES: A CASE STUDY FROM MCNAUGHTON CREEK, BRITISH COLUMBIA

by

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ABSTRACT: The stabilization of roadfills on abandoned forest roads is a key component of forest road deactivation. Deactivation requires the use of tracked excavators to retrieve potentially unstable roadfills and restore hillslope hydrology. In cases where access for tracked excavators is not possible or too costly, explosives can be used to stabilize roadfills at isolated or intermittent locations. A methodology for using explosives to stabilize roadfills at McNaughton Creek, British Columbia is discussed.

KEYWORDS-- forest road stability, deactivation, stormproofing, explosives

## INTRODUCTION

Deactivation, or the "deconstruction" and "stormproofing" of abandoned forest roads, is often carried out to prevent landslides (Moore, 1994). Deactivation consists of restoring the hillslope drainage paths to pre-road conditions, stabilizing roadfill by retrieving fill which may initiate landslides, and rehabilitating the road corridor to increase site productivity (Baumann et al, 1995).

While most roads can be deactivated using tracked excavators, a number of areas

that require deactivation that are inaccessible or not economically feasible to deactivate using excavators. In these situations, explosives may be used to deactivate areas with comparable cost and satisfactory results.

Although the use of explosives may cause a landslide, due to controlled factors the landslide is smaller and drier than if no action is taken, and poses less risk to the environment. Before deactivation with explosives is performed, a detailed site investigation and cost analysis should be completed to ensure that the use of explosives is the best geotechnical, environmental and financial option.

SITE CONSIDERATIONS

Logging road construction on steep, glacially oversteepened slopes was commonly carried out in coastal B.C. using cut and fill methods. Such roads on landslide-prone terrain, once abandoned, have been proven to be unstable in numerous cases. Deactivation using tracked excavators is the best means to stabilize these sites, but the lack of access can make the use of tracked excavators cost prohibitive.

The use of explosives as an alternative method for stabilization should be considered if the road requires roadfill retrieval at isolated locations and contains one or more of the following characteristics:

- the immanent failure at the site would cause significant damage, possible serious injury, or death, and time is not available to mobilize tracked equipment to the site;
- drainage structures or bridges that have been previously removed or washed out, eliminating access;
- remote location where mobilization costs (i.e. barging) may exceed 25% to 40% of the project cost;
- where previous deactivation (roadfill pullback) has eliminated access.

If the site conditions dictate that blasting is a possible option, a cost comparison should be carried out to determine if the use of explosives is feasible. Items to be included in the cost estimate are:

- number of crew required;
- access requirements (helicopter, ATV, or foot) and travel time;
- day rate of licensed and qualified blaster and assistants;
- costs of explosives, magazine rental (if

required), and miscellaneous supplies;
- mobile blast shelter for crew, if needed;
- training or monitoring, if needed.

METHODOLOGY

The use of explosives for deactivation has been carried out on a trial basis for both stabilizing roadfills and removal of culverts (Erickson, 1994). For roadfills, explosives must be located near the face of the slope and buried so that the energy of the blast is forced down and outwards. It is important to achieve as much depth as possible during blasthole excavation, since explosive effectiveness greatly increases with depth of burial. Since access is limited, hand tools are typically the only means of blasthole excavation and it is often necessary to perform two separate blasts.

The first blast is small and intended to create " springholes" . The first step is to use a large metal bar to make small, deep holes in the soil. These holes are placed about 4ft (1.3m) apart, with a minimal depth of 2ft (0.6m), and along a line with a suitable burden for the second blast. Each hole is then loaded with stick powder, approximately 1 stick for every 1m of hole depth, backfilled with soil, and detonated with no delays. It is also important to blast any key stumps or large logs at the toe of the roadfill.

The result is loose soil around each barred hole that may be excavated to a depth and diameter much larger than excavating using a metal bar alone. This loose soil is mucked out with shovels and the metal bar and loaded with stick powder and bulk explosives (AMEX or ANFO) for the second blast. Approximately 3kg of explosive is suggested for every 0.3m of hole depth in dry conditions for the second blast. Backfilling the holes with well graded gravel is done to confine the blast and help direct the energy of the explosive laterally towards the roadfill. The holes are detonated simultaneously for the greatest amount of heave.

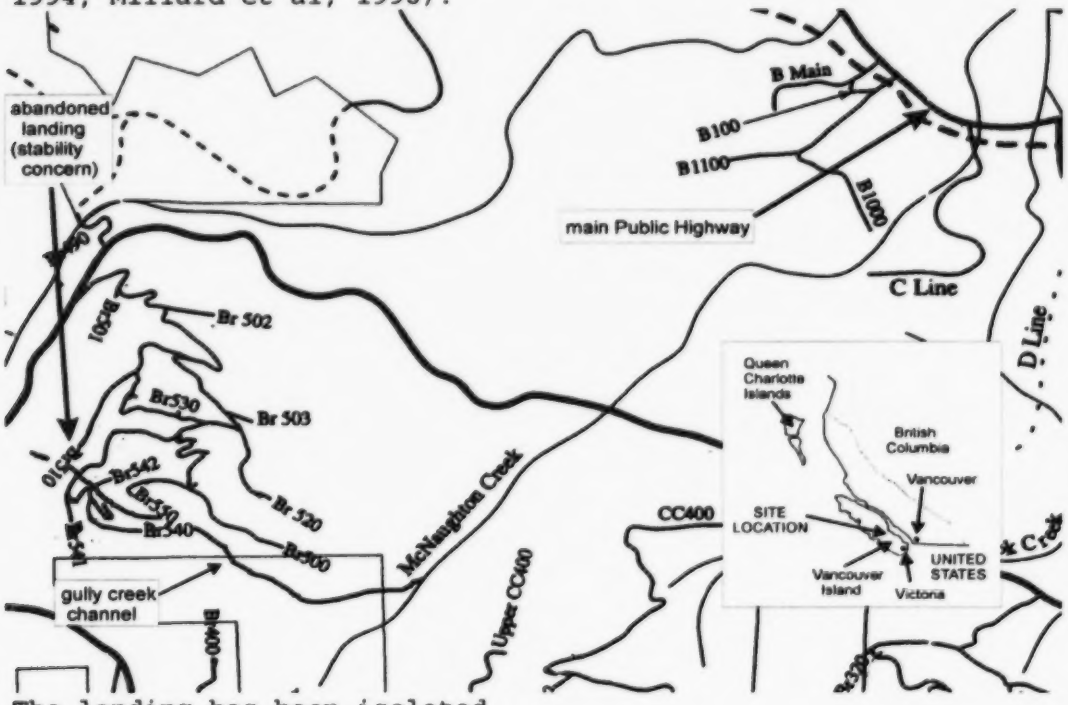
The intent of the second blast is to throw material down the slope in a dispersed manner. This increases stability of the site by unloading the top of the fill, and does not significantly decrease the stability of downslope areas. Note that further blasts may be required if roadfill remains.

Figure 1: Location (inset) and site map.

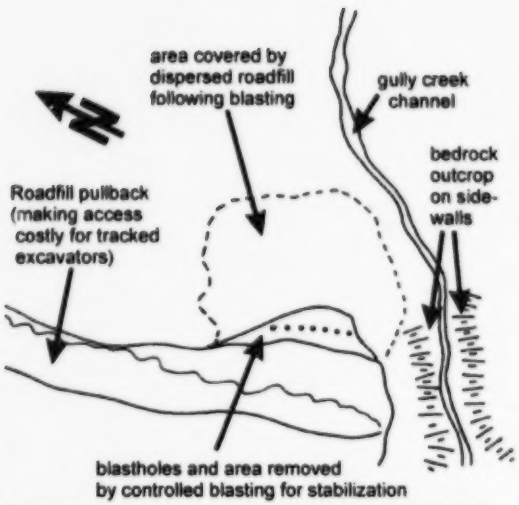
CASE STUDY: McNaughton Creek Landing Deactivation

The McNaughton Creek watershed is located on the East coast of Vancouver Island, approximately 20km south of Courtenay (Figure 1). The site is an abandoned landing, at an elevation of about 1000m and adjacent to a first order creek gully. These landforms are known to be prone to landslides following clearcut harvesting (Rollerson et al, 1994; Millard et al, 1998).

by previous deactivation, situated at the end of a 650m spur road of permanently deactivated logging road (Figure 2, Photo 3). Access to the landing is by foot only and several trips were required to transport explosives, lay blasting wire, and keep a safe distance from the blast area.




The landing has been isolated


area covered by dispersed roadfill following blasting
gully creek channel
bedrock outcrop on side-walls
Roadfill pullback (making access costly for tracked excavators)
blastholes and area removed by controlled blasting for stabilization
Figure 2: Site sketch showing landing and creek gully channel

The surficial materials in the area are a morainal veneer with minor amounts of colluvium. Construction of the landing created an oversteepened fill slope, containing a mixture of soil, blasted rock, logs and supporting stumps left in place. As a result of yarding, a large amount of LWD (large woody debris) had accumulated on top of the fillslope. The landing fillslope was measured as greater than 50E. A small landslide, approximately 7 to 10 ft (2 to 3m) wide, occurred at the north end of the landing and terminated in the gully below. This small event occurred some time after the site was deactivated. A large tension fracture, located about 15ft (5m) from the eastern edge of the roadfill and approximately 30ft (10m) in length, was also found, indicating that a much larger failure was likely.

The slopes below the landing are oriented directly above the first order gully. If failure were to take place, debris would flow directly in the gully and sediment would be transported to Rosewall creek, causing a significant impact on fish habitat. If the debris slide from the landing were to initiate a larger debris flow event, the residential development and highway could be impacted.

Following a detailed investigation of the landing, blasting was deemed to the most cost effective method to stabilize the slope. Three blasts were required to complete the project, requiring two field days. The first blast removed the LWD, while the second blast created springholes for the third blast. The final blast produced a controlled debris slide to remove fill material, and stabilized the slope.

Blasts A and B: Springholes and LWD Removal - The ground near the outer edge of the landing was compacted and contained many boulders. Seven springholes were located

as close to the LWD as possible, approximately 4.3ft (1.3m) apart and bored with a heavy iron bar and shovel suitable for stick explosives (Fig 3). A generic 1" by 8" emulsion stick was used to create a high energy, low heave blast to loosen the soil. After the sticks were placed in the bottom of each hole, the holes were backfilled with dirt to original ground level and detonated simultaneously. The linear length of roadfill stabilized was about 33ft (10m). Table 1 presents the data for the springholes.

Table1: Springhole Data

| Springhole # | Depth ft (m) | # of Sticks |
|---|---|---|
| 1 | 3 (1) | 2/3 |
| 2 | 4.3 (1.3) | 1 |
| 3 | 3 (1) | 1 |
| 4 | 2 (0.6) | 3/4 |
| 5 | 3 (1) | 1 |
| 6 | 4.3 (1.3) | 1 |
| 7 | 4.3 (1.3) | 3/2 |

Figure 3: Using a metal bar to excavate springholes for last A.

After this blast, the springholes were mucked out with shovel and heavy steel bar, filled with plastic bags containing AMEX II bulk explosive (ANFO), and backfilled to the ground surface. A single stick was used a primer in the bottom of each springhole. Data for the LWD blastholes are given in Table 2.

Table 2: LWD Blasthole Data

| Hole # | Depth ft (m) | AMEX lb (kg) | # of Sticks |
|---|---|---|---|
| 1 | 4.3 (1.3) | 22 (10) | 1 |
| 2 | 3.6 | 22 | 1 |

| | | | |
|---|---|---|---|
| | (1.1) | (10) | |
| 3 | 2.5<br>(0.8) | 22<br>(10) | 1 |
| 4 | 3<br>(1) | 22<br>(10) | 1 |
| 5 | 4.3<br>(1.3) | 22<br>(10) | 1 |
| 6 | 3<br>(1) | 22<br>(10) | 1 |
| 7 | 4<br>(1.2) | 22<br>(10) | 1 |

Figure 4: Excavation of springholes using a hand shovel.

The blasthole charges were detonated simultaneously to create the most heave, projecting material as far as possible. The amount of AMEX II used per hole reflected the dry moisture conditions. Immediately to the north of the 7th hole, two large stumps were located approximately 10ft (3m) downslope from the edge of the landing. A charge of 80lbs (35kg) of was placed at the base of these stumps in an attempt to remove them and initiate the movement of the LWD amongst, and below these stumps. This charge were detonated in conjunction with the holes.

The results from this blast were satisfactory. A significant amount of LWD was dislodged from the landing and a 10 to 13ft (3 to 4m) wide bench was created as a staging area for the second blast.

Blast C: Fill Removal - Preparation of the fill removal blast began on the second day. Adequate ground disturbance from the LWD blast allowed holes to be dug for the fill removal blast without the need of springholes. The blastholes were positioned with a burden of 10 to 13ft (3 to 4m) from the edge of the

landing, at the break in slope of the bench created by the LWD blast. Six blastholes, spaced 4.3ft (1.3m) apart, were detonated simultaneously using 1 stick per blasthole as a primer. Proportionally more bulk explosive was added to each blasthole due to the increased moisture content of the soil from overnight rainfall (Table 3).

Table 3: Fill Removal Blasthole Data

| Hole # | Depth ft (m) | AMEX lb (kg) | # of Sticks |
|---|---|---|---|
| 1 | 2.5 (0.8) | 33 (15) | 1 |
| 2 | 2.5 (0.8) | 33 (15) | 1 |
| 3 | 2.5 (0.8) | 33 (15) | 1 |
| 4 | 2.5 (0.8) | 33 (15) | 1 |
| 5 | 2.5 (0.8) | 33 (15) | 1 |
| 6 | 2.5 (0.8) | 33 (15) | 1 |
| 7 | 1.5 (0.5) | 22 (10) | 1 |

There was evidence of material blown back towards the western, stable area of the landing. This debris is most likely from blasthole #6, where the short depth of 1.5ft (0.5m) was likely inadequate to confine the charge and force the blast energy downwards.

Time and Cost Estimates - The costs for this project were recorded to determine unit prices for individual tasks. Table 4 presents time and cost estimates. The unit cost of this project was $7.70/m$^3$ ($70/lin m) of material removed, not including of mobilization costs.

**Table 4: LWD Blast Time and Cost Estimate (excludes transportation costs)**

| Task / Product | Man Hours / Total | Unit Cost | Total Cost ($) |
|---|---|---|---|
| dig springholes | 3.5hr | $45.00/hr | 160.50 |
| load springholes | 0.5hr | $45.00/hr | 22.50 |
| dig LWD holes | 3.5hr | $45.00/hr | 160.50 |
| load LWD holes | 0.5hr | $45.00/hr | 22.50 |
| dig Fill removal holes | 3.0hr | $45.00/hr | 135.00 |
| load Fill Removal holes | 0.5hr | $45.00/hr | 22.50 |
| sticks | 20 sticks | $.72/stick | 14.40 |
| AMEX II, lbs (kg) | 310 (140) | $0.43/lb ($0.20/kg) | 133.30 |
| CORDTEX 25, ft (m) | 100 (30.5) | $0.16/ft ($0.52/m) | 16.00 |
| safety fuses | 3 | $2.20/fuse | 6.60 |
| | | **Total*** | **693.80** |

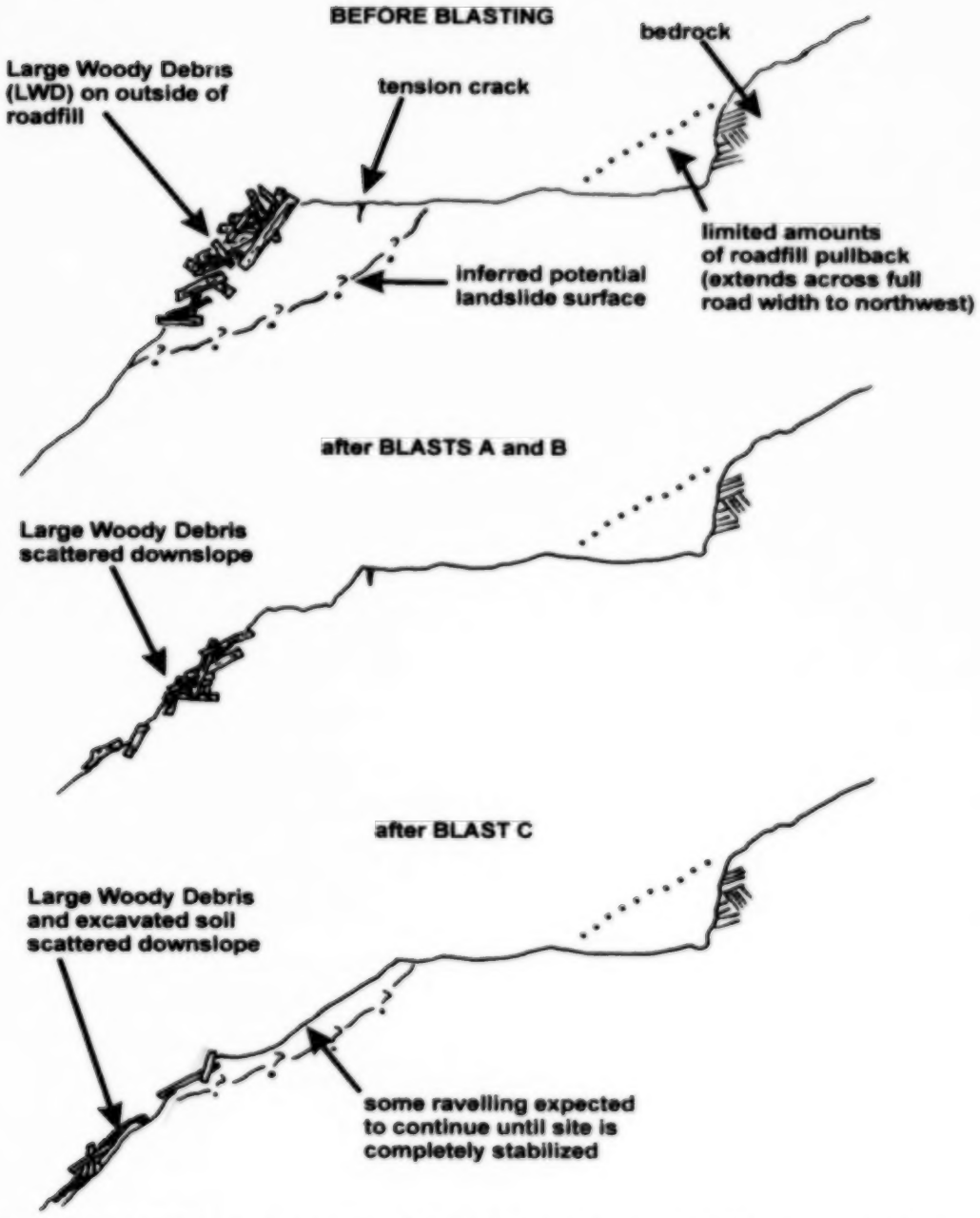



Figure 5: Cross sections of landing and roadifill slope before and after blasting.

Conventional deactivation methods using a large tracked excavator range between 3 to $10/yd$^3$ , independent of mobilization, access, and demobilization costs. In this example, these costs would be extremely high, taking into account the time required to transport the excavator to the site and reconstructing 650m of fully deactivated logging road to access the landing. It should also be noted that some decreased costs would be realized if a larger scale project was carried out.

## SUMMARY

The use of explosives for road deactivation may be the best option in remote areas, locations where access has been lost, or regions where work is required for isolated locations. A detailed site investigation and cost analysis must be carried out to ensure that blasting techniques will provide a sound geotechnical, environmental and cost effective solution. As demonstrated at McNaughton Creek, the use of explosives can be an adequate and cost effective stabilization technique to reduce the likelihood of landslides from unstable roadfills.

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